Preliminary Computation of Evapotranspiration by Land Cover Type Using Landsat TM Data and SEBAL

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Abstract—**The Boise Valley of Idaho, USA, has a semi-arid climate with approximately 20 to 30 cm of precipitation per year. The predominant land use type has been agriculture, with approximately 370,000 irrigated hectares. Over the last 20 years, the valley has grown in population from 257,000 in 1980 to 431,000 in 2000. An important issue facing water planners is water availability in a valley that is changing from mostly agricultural land-use to more urban types of land use. Department planners have gained insight into the problem by combining LULC polygons from aerial photograph interpretation, and evapotranspiration from Landsat TM data as processed through the Surface Energy Balance Algorithm for Land, both for the year 2000. Seasonal evapotranspiration was generated for the period March 15, 2000 to October 15, 2000. The product was an "image" of seasonal evapotranspiration. LULC polygons were overlaid on the evapotranspiration image and the mean evapotranspiration was computed for all polygons of each LULC class. The preliminary results show that "Irrigated Agriculture" used 812 mm of water, "Urban Residential" used 684 mm, and "New Subdivision" used 606 mm. The water use for irrigated agriculture should be regarded more reliable than for the other two classes, although the error rate is probably not great.**

Keywords-Evapotranspiration, SEBAL, land use, land cover

INTRODUCTION

The Boise Valley in southwestern Idaho is approximately 1,600 square miles in size. The predominant land uses are irrigated agriculture (41%), urban and built-up (10%) and rangeland (32%). The average annual precipitation in the valley is approximately 30 centimeters.

The purpose of this project was to compute the amount of evapotranspiration (ET) by land use/land cover (LULC). Planners understand how the demand for water will be affected by the transition of land from irrigated agriculture to residential, commercial, and industrial LULC types.

This study was designed to support water planning in the Boise Valley. Planners had limited data on the different water use by different LULC classes, and needed better data to plan for future water availability with the conversion of irrigated agriculture to other LULC classes.

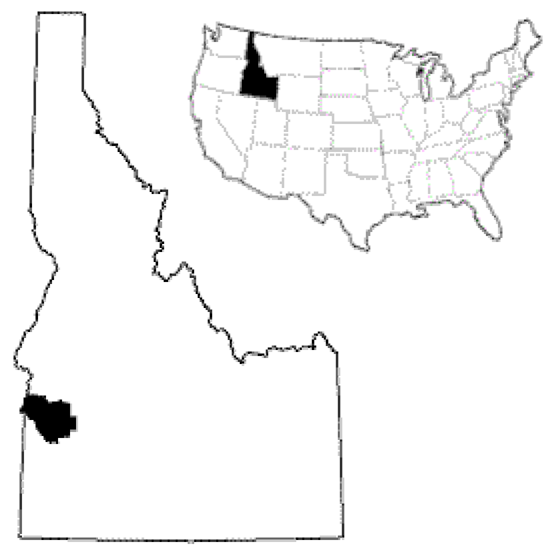

Figure 1. Location of the Lower Boise Valley, Idaho

LAND USE / LAND COVER MAPPING

IDWR computed and mapped ET by LULC class because of the convergence of three IDWR projects. Two of the projects were done in cooperation with the U.S. Bureau of Reclamation.

IDWR, working cooperatively with the U.S. Bureau of Reclamation mapped LULC polygons from 1:24-000-scale, color infrared, aerial photography taken during the summer of 2000. The aerial photographs were scanned to 1.5-meter pixels and registered to the Idaho Public Land Survey System base. The registered photographs were mosaicked into tiles that covered an area of approximately 93 square kilometers. IDWR personnel developed comprehensive descriptions of 24 LULC classes for the project. The descriptions were modified from [1] and are available in [2].

EVAPOTRANSPIRATION COMPUTATION

ET was computed and mapped using the Surface Energy Balance Algorithm for Land (SEBAL). SEBAL is an image-processing model. It uses Landsat TM data, (both reflected and thermal), wind speed, solar radiation, dew point temperature, air temperature, and reference ET data as input to compute radiation and an energy balance for the earth's surface, and fluxes of sensible heat and evapotranspiration for each Landsat pixel. A detailed description of SEBAL is provided in [3] and [4]**.** The Idaho implementation is described in [5], [6], and [7]. For this analysis seven dates of Landsat data were processed between March 15 and October 15, 2000.

ET BY LAND / USE LAND COVER CLASS

The availability of detailed LULC classes has enabled IDWR to overlay the LULC classification with the SEBAL ET data to generate ET by land cover class, data that were not previously available. IDWR personnel overlaid the LULC polygons (Figure 2) on the "image" of seasonal ET (Figure 3) and computed the average seasonal ET from all the polygons of each class. The result is Figure 4, from which Table 1 is generated. Table 1 shows the mean ET by LULC class with the associated standard deviation.

The results show that older residential areas use about 13% more water than new subdivisions, and that irrigated agriculture uses about 19% more water than older residential areas, and about 34% more water than new subdivisions. The differences in residential water use are probable due to differences in landscape maturity.

The SEBAL model has been geared toward estimating agricultural ET, and residential areas have different characteristics than agricultural land. Preliminary analysis indicates there is some error associated with ET for residential land use, but that the maximum error is relatively small. A reasonable approximation of the maximum error induced by the differences is 1.5 mm per day at peak summer temperatures. In terms of the total seasonal ET, the error in the urban classes is probably between 15% and 20%.

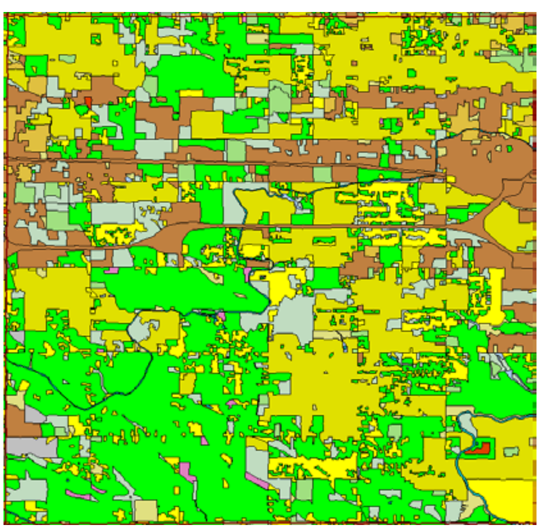

Figure 2. Land use/land cover polygons in T3NR1E of the Boise Valley

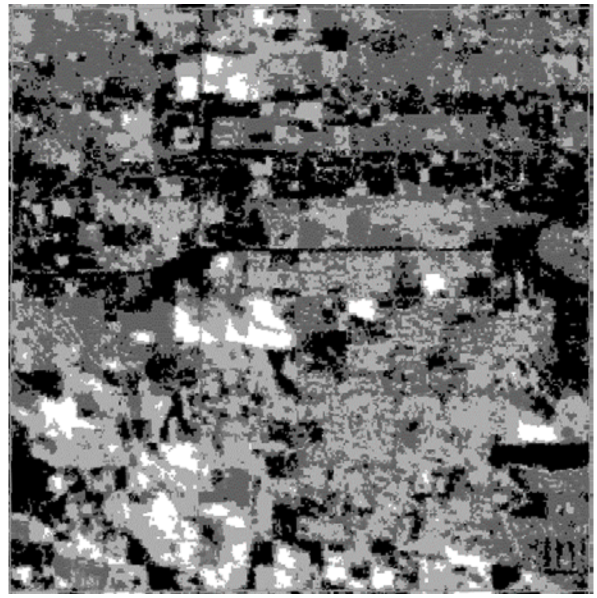

Figure 3. ET image of T3NR1E the Boise Valley.

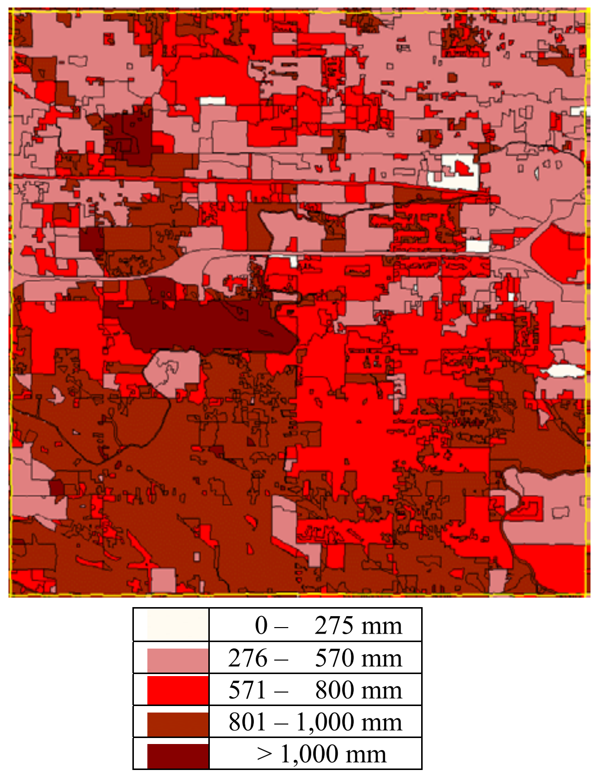

Figure 4. Land use / land cover polygons color coded for mean ET.

The significance to the ET data presented in Table 1 is that all interested parties now have one, consistent, local dataset that they can use as the basis for discussing solutions to issues, rather than debating the relative merits of each other's data.

Table 1. Mean seasonal ET by land use/land cover class.

Class Name	Seasonal ET in MM	Standard Deviation in MM	Area in Hectares
Wetland	1,025	285	5,862
Water	924	165	5,344
Recreation	826	252	2,057
Perennial	820	212	2,711
Irrigated Crops	812	189	141,075
Canal	731	203	2,745
Urban Residential	684	157	4,126
Rural Residential	657	192	10,164
Farmstead	609	188	2,243
New Subdivision	606	146	11,516
Sewage	552	256	232
Public	548	263	2,120
Other Agriculture	536	243	2,853
Dairy	524	182	604
Feedlot	479	205	1,691
Junk Yard	467	193	129
Abandoned Agriculture	459	211	1,837
Transition	437	195	2,712
Idle Agriculture	436	215	3,042
Transportation	420	222	2,313
Commercial and Industrial	380	196	5,762
Barren	335	258	1,912
Unclassified	298	239	12,742
Rangeland	242	160	90,647
Petroleum Tanks	237	112	18

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